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# TEMPERATURE JUMP PYROLYSIS STUDIES OF RP-2 FUEL

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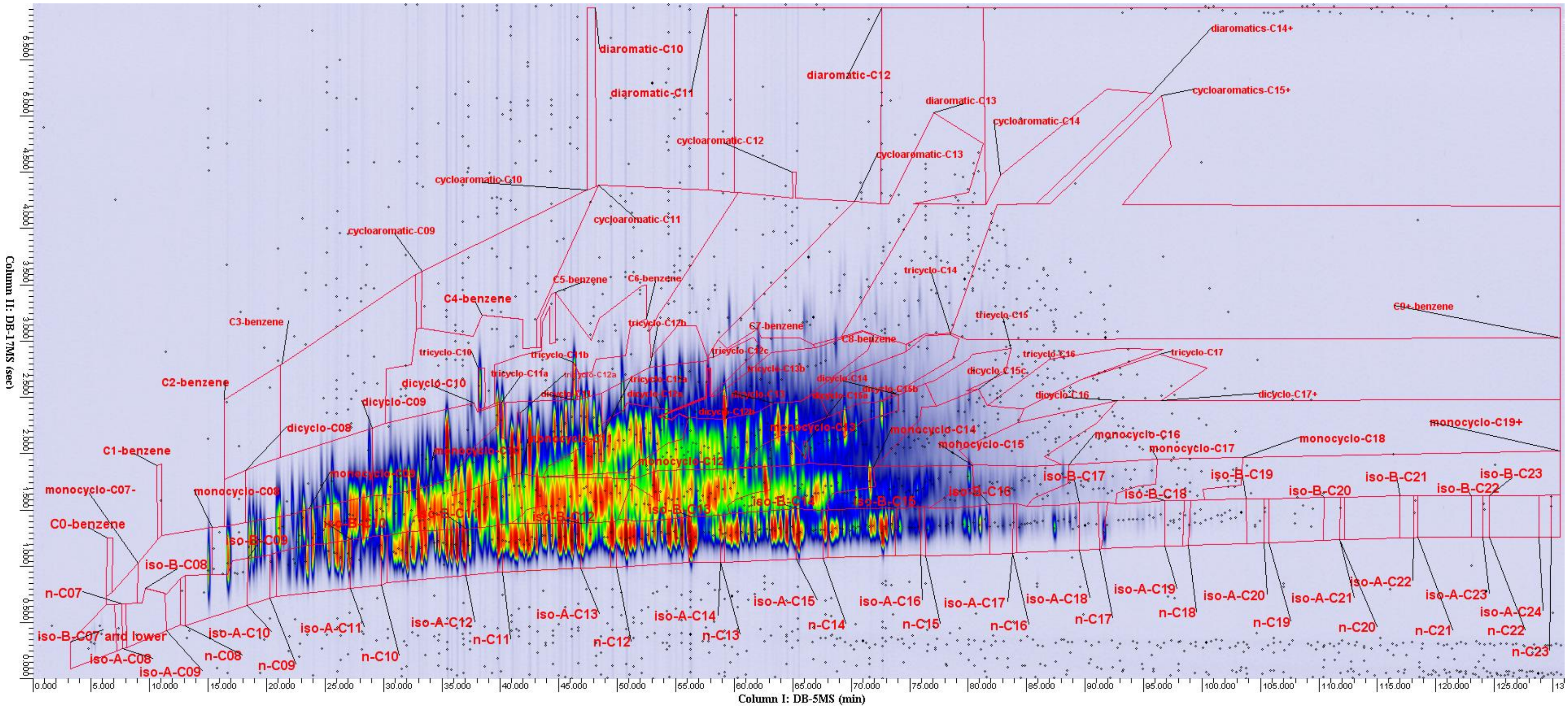
# Understanding RP-2: A Complex Mixture

RP-2 is a real fuel consisting of hundreds of different compounds; comprised primarily of kerosene

There is little sulfur containing compounds and almost no aromatics in the fuel

| Type of Compound | RP-2 wt% | Jet A wt% |
|---|---|---|
| Aromatics | 0.28 | 18.66 |
| iso-Paraffins | 36.61 | 29.45 |
| N-Paraffins | 2.42 | 20.03 |
| Cycloparaffins | 60.69 | 31.86 |

# Understanding RP-2:  A Complex Mixture





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# RP-2 Pyrolysis/Combustion Chemistries?

- Recent studies have focused on the understanding of real fuel chemistry
  - MacDonald et al. (JPP, 2007): e.g., RP-1, RP-2, JP-7
  - Fortin and Bruno (Energy Fuels, 2013): e.g., Thermally stressed RP-1 and RP-2

- We are interested in coking kinetics
  - Allows fundamental modeling of the chemical kinetics involved during thermal stressing
  - Data also useful for engine performance modeling

# Motivation:  Understand Coking Mechanisms

Coking:

Deposits are formed along the walls of the cooling channels

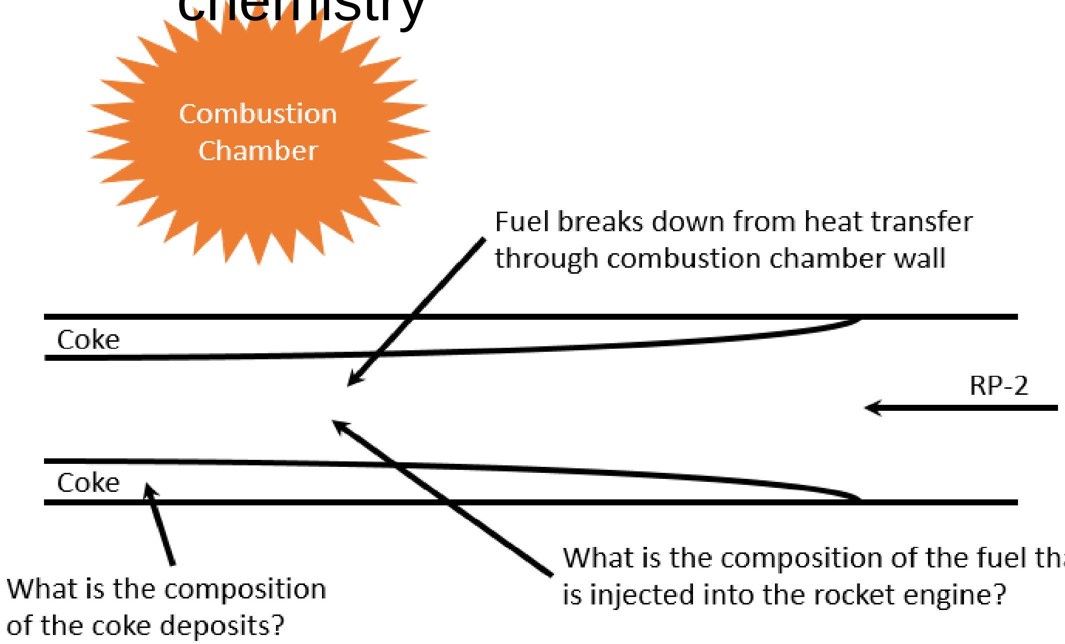
Causes restricted fuel flow

Leads to increased exposure to thermal stressing

Fuel Composition Changes:

Liquid to gas transition in cooling channels

Causes break down due to gas-phase pyrolysis and surface chemistry



# Objectives of This Work

What is actually being burned in the engine?

What is the effect of the channel wall material on coking?

How accurate are the measurements being performed when burning real fuels in experiments?

# Temperature Jump Pyrolysis at AFRL Edwards

Rapid heating of a metal filament at a rate of 600 – 800 K/s, and the set temperature is held for around 20 seconds

The method has been used to understand the decomposition of a variety of different compounds

The method is commonly attached to an FTIR spectrometer to measure the products of pyrolysis under different conditions

# FTIR Experimental Setup

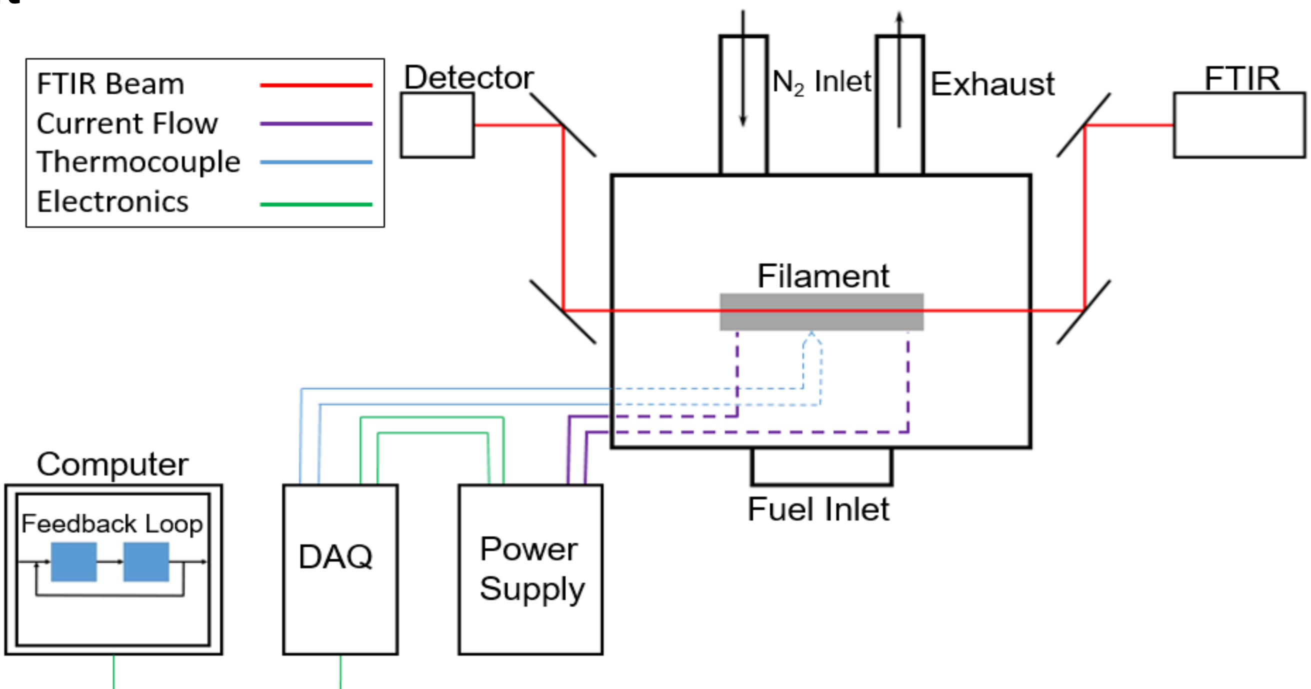
System powered through a 40V/15 A power supply

- Up to 600 K/s
- T = 300 – 600 ± 20 $^{o}$C
- P = 1 – 30 atm
- Nichrome Filament

Rapid-scan FTIR

- 590 – 3850 $cm^{-1}$ with 4 $cm^{-1}$ res
- 256 Scans at 180 kHz

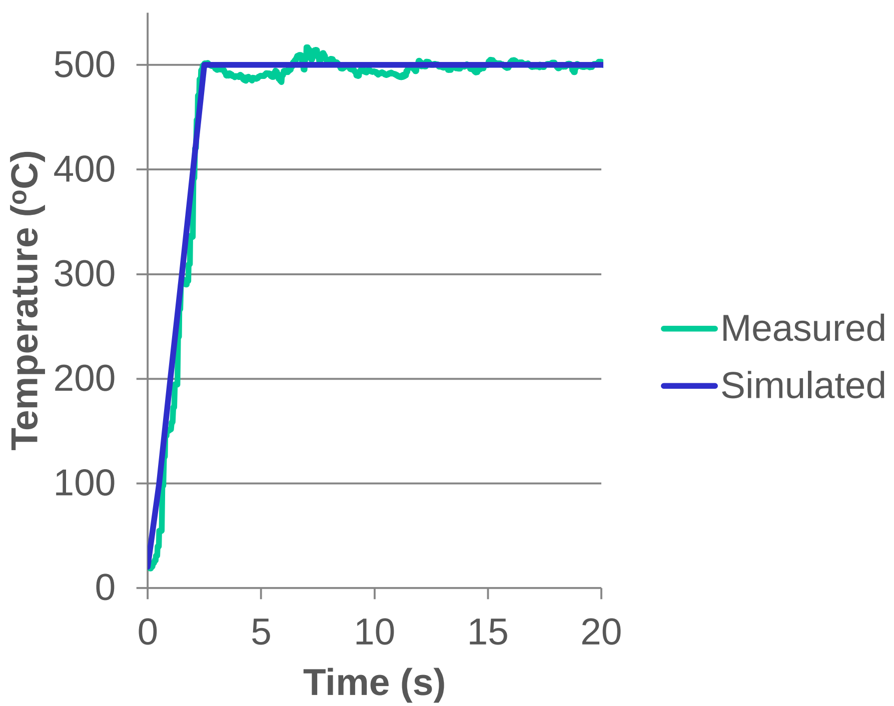
Labview controlled PID controller and FTIR trigger

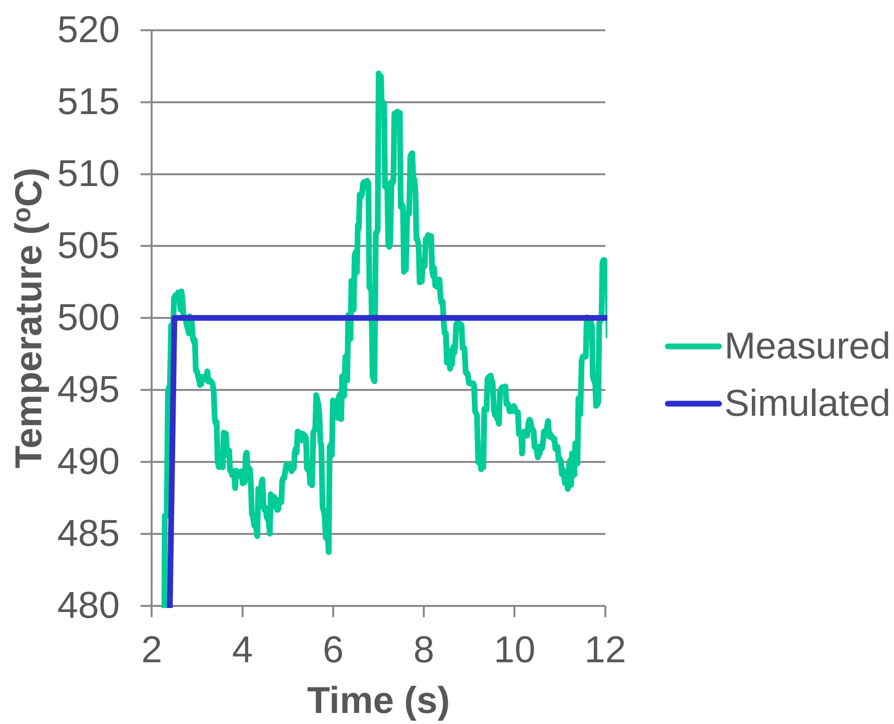


# Results and Discussion: Temperature Rise Measurement

Water experiment

- T = 500 $^{o}C$
- dT/dt = 200 $^{o}C$



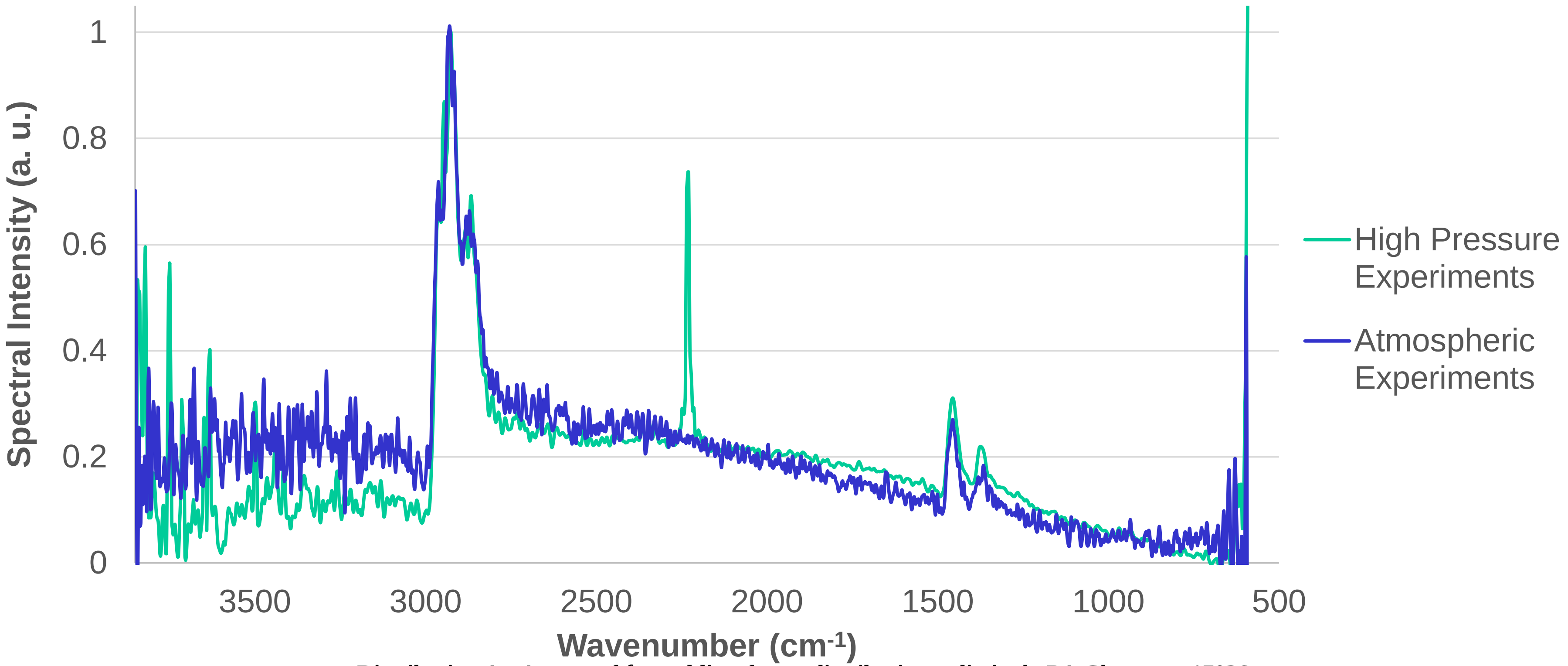



# Results and Discussion: RP-2 Spectrum

C-H Stretch at ~2950 $cm^{-1}$

C-C Stretch at ~1450 $cm^{-1}$

C≡C Stretch at ~2235 $cm^{-1}$

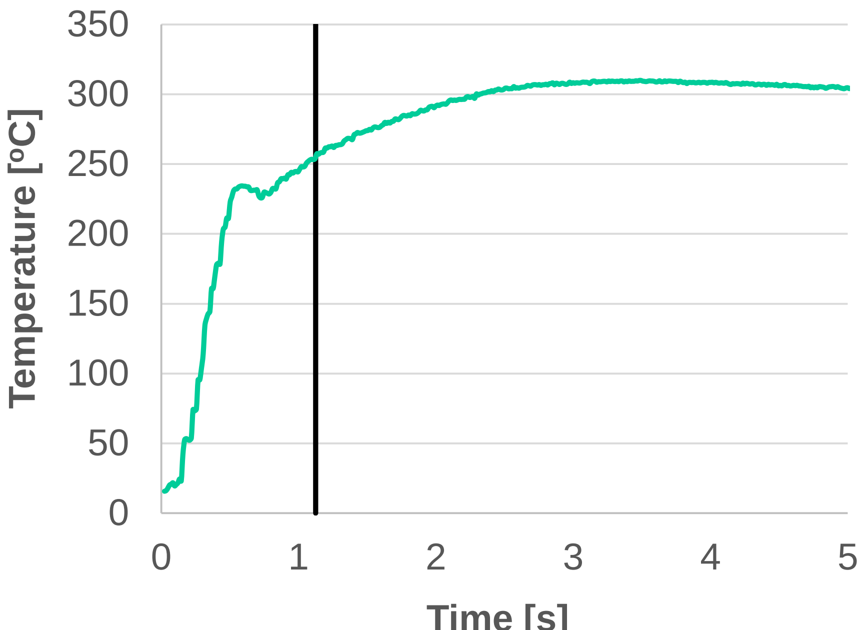


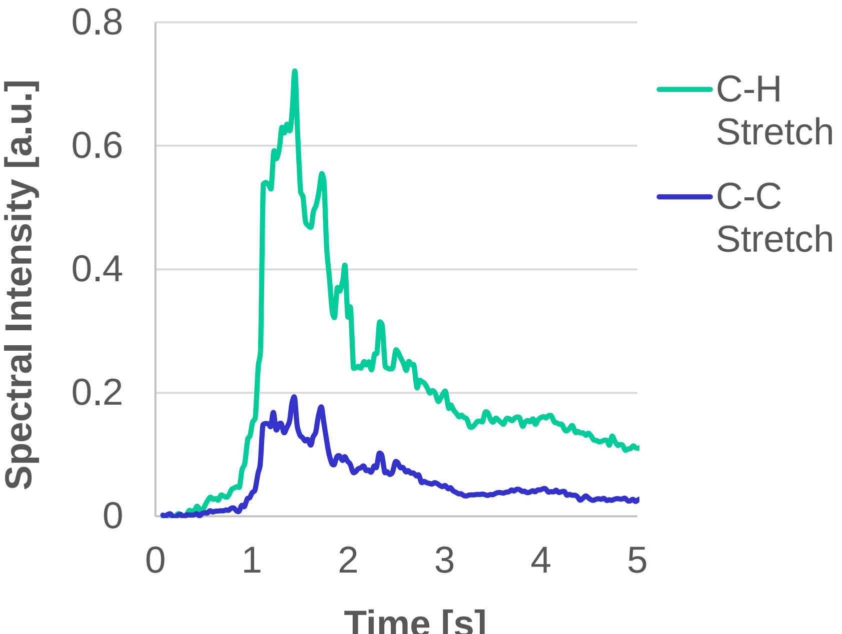
# Results and Discussions: Time Histories

Time-history of 2 major wavelengths compared to temperature

C-H Stretch: 2927 $cm^{-1}$

C-C Stretch: 1514 $cm^{-1}$



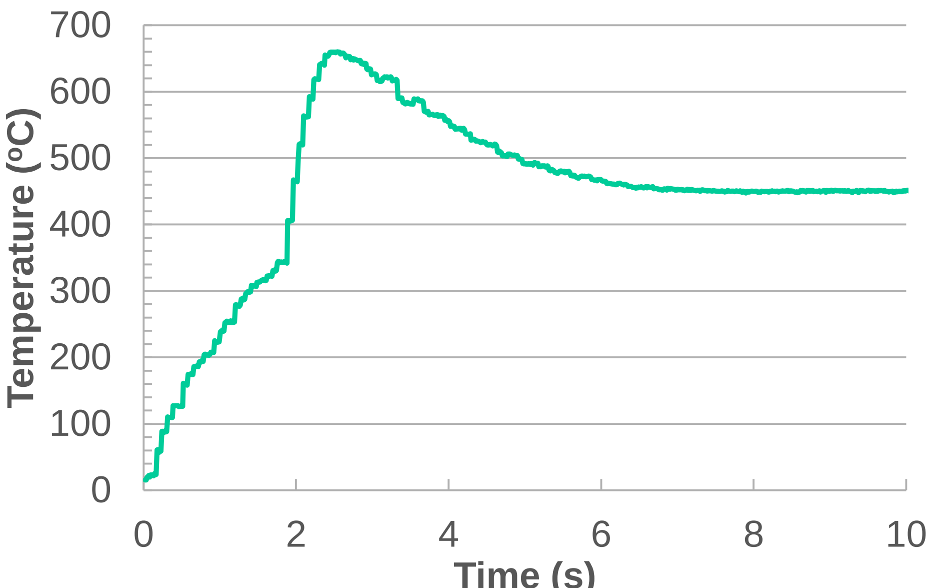



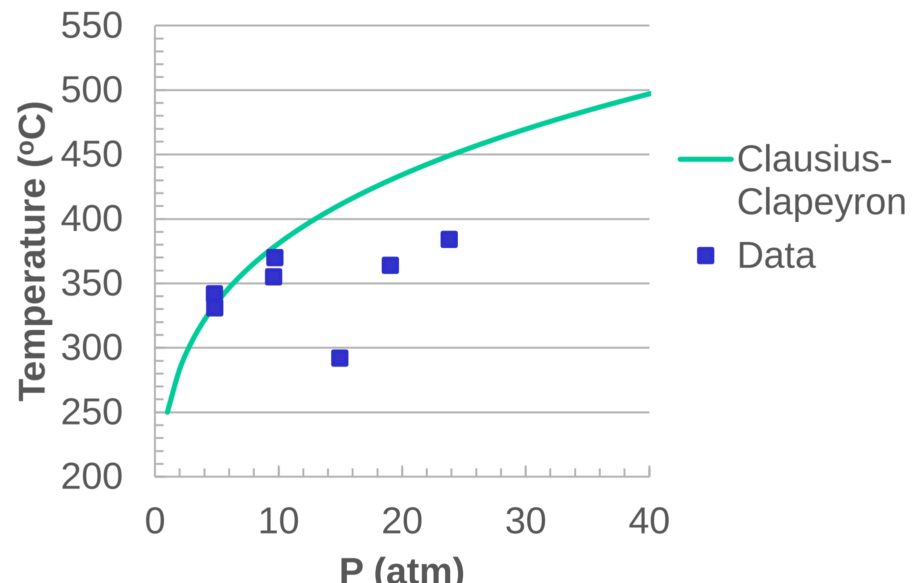
# Results and Discussion:  Boiling vs. Pyrolysis

The temperature rate increase slowed with addition of RP-2 to the system

The inflection point shows the location of the boiling point

The Clausius-Clapeyron equation is able to match the boiling below 10 atm



# Future Work and Improvements

Accelerate the rate of temperature increase to avoid boiling

Perform measurements with different surfaces

Perform measurements at elevated pressures

Identify the different compounds that are being produced at different pressures

Examine any solid compounds left behind upon RP-2 pyrolysis

# Conclusions

T-Jump / Rapid-scan FTIR experiments were performed at elevated pressures

A new spectral line is observed at elevated pressures

Issue of boiling of RP-2 on the surface of filament needs further investigations

More studies need to be done to understand how different surfaces affect the breakdown of RP-2

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